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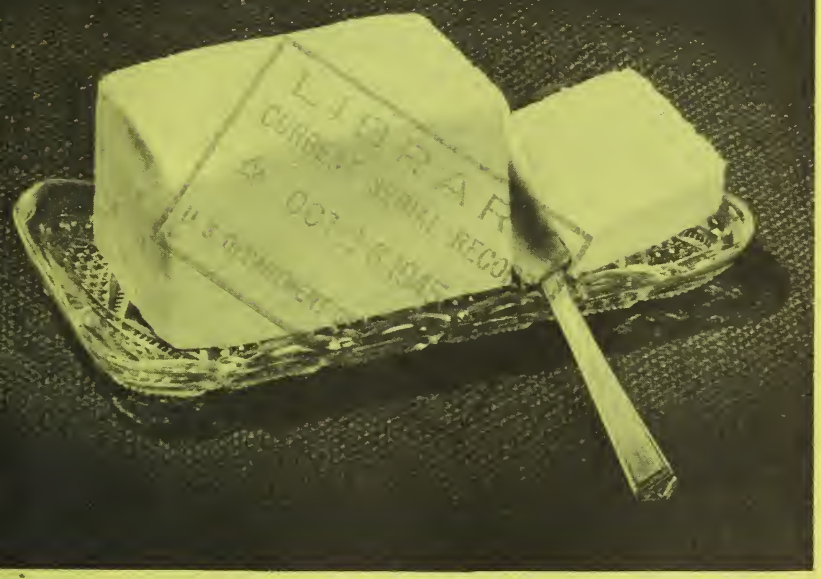
Vitamin A in Butter



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FOREWORD

Early in 1941 the Committee on Food and Nutrition (now the Food and Nutrition Board) of the National Research Council transmitted a proposal to the Secretary of Agriculture recommending that studies be undertaken to determine the normal variation in the vitamin A values of milk and butter as affected by seasonal and regional feeding practices, and also the actual variation in the vitamin A values of market butter as sold in the towns and cities in different regions.

The Secretary forwarded the recommendation to the Bureau of Dairy Industry and the Office of Experiment Stations, Agricultural Research Administration. Representatives of these Department agencies outlined a plan of procedure and presented it to the directors of the State agricultural experiment stations during their annual meeting in Chicago, in November 1941, with the result that a Nation-wide cooperative survey was approved.

The directors of the State experiment stations designated C. H. Bailey, Director of the Minnesota Agricultural Experiment Station, to work with O. E. Reed, Chief of the Bureau of Dairy Industry, and James T. Jardine, Chief of the Office of Experiment Stations, as a committee to develop cooperative plans for the study, to assume over-all administrative direction of the project, and to appoint a Technical Committee to formulate the analytical methods and procedures.

The Technical Committee was composed of the following scientists: L. A. Maynard, New York (Cornell), chairman; C. J. Koehn, Alabama; H. R. Guilbert, California; F. P. Zscheile, Jr., Indiana; G. W. Snedecor, Iowa; L. S. Palmer, Minnesota; I. L. Hathaway, Nebraska; W. H. Peterson, Wisconsin; and C. A. Cary, Bureau of Dairy Industry. Later, C. A. Cary was made chairman, W. D. Salmon of Alabama succeeded C. J. Koehn, and W. F. Geddes of Minnesota succeeded L. S. Palmer.

The first responsibility of the Technical Committee was to organize and undertake such cooperative work as was necessary to develop suitable methods for obtaining samples of butter and for determining its carotene and vitamin A content. Meantime, plans were developed and arrangements were made for participation by State experiment stations that were so located as to be able to provide data fairly representative of the butter produced in the United States.

After a year's cooperative work, the Technical Committee made recommendations regarding methods of obtaining butter samples and determining their vitamin A potency. These methods were approved by all agencies participating in the study and, in all essential respects, these were the ones used in the analytical work and in compiling the results. The Technical Committee worked closely with the State leaders throughout the study and also assumed the responsibility for the compilation and evaluation of the data.

The study itself and the organization necessary to undertake it have been complex and the work has been carried to completion with difficulty under war conditions. The organization, procedures, and results will stand as an example of what can be accomplished by voluntary cooperation.

P. V. Cardon

Administrator, Agricultural Research Administration.

A NATION-WIDE SURVEY

To determine the importance of butter as a source of vitamin A in the diet of the people of the United States, a Nation-wide survey was made by the Bureau of Dairy Industry and the Office of Experiment Stations, Agricultural Research Administration, United States Department of Agriculture, in cooperation with 20 State agricultural experiment stations.

Cooperating Agencies and Project Leaders

Alabama	W. D. Salmon
California	G. A. Richardson
Idaho	D. R. Theophilus and O. E. Stamberg
Indiana	B. E. Horrall
Iowa	E. W. Bird
Kansas	J. S. Hughes and W. H. Martin
Louisiana	E. A. Fieger
Maryland	C. W. England
Minnesota	L. S. Palmer and Robert Jenness
Mississippi	Marvin Gieger
Montana	J. A. Nelson
Nebraska	I. L. Hathaway
New York (Cornell)	B. L. Herrington
North Carolina	W. J. Peterson
Ohio	W. E. Krauss
Oregon	J. R. Haag
Pennsylvania	R. A. Dutcher and N. B. Guerrant
Washington	U. S. Ashworth and Margaret McGregor
Wisconsin	W. H. Peterson
Wyoming	H. S. Willard
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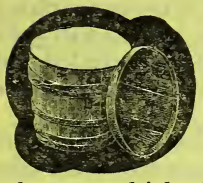
VITAMIN A IN BUTTER

Prepared by the Bureau of Dairy Industry



Vitamin A is essential for life and health in people of all ages. Nutritionists and other authorities generally recognize that butter is a rich source of this essential vitamin. The total vitamin A potency of butter depends on the amount of colorless vitamin A it contains and also on its carotene content. Carotene, the substance which gives butter its natural yellow color, is converted into vitamin A in the body.

In order to answer certain practical questions raised by the Food and Nutrition Board of the National Research Council early in 1941 concerning the importance of butter as a source of vitamin A in the diet of the people of the United States, the agricultural experiment stations in 20 States, the Bureau of Dairy Industry, and the Office of Experiment Stations inaugurated a Nation-wide study of the vitamin A potency of the butter produced and marketed in different seasons of the year and in different regions.

Prior to the survey it was recognized that the vitamin A potency of milk, as well as that of the butter made from it, varied according to the feed given the cows and that summer feeding conditions differed from winter feeding conditions in most regions of the country. Many investigators had shown that butter produced in summer was generally much richer in both vitamin A and carotene than butter produced in winter. But the actual vitamin A potency of all the butter produced and sold in this country was unknown, and no information was available to show the relative amounts of summer and winter butter consumed by the average person nor the time of year when the bulk of the summer or winter butter was actually marketed or consumed. Such information was wanted by the Food and Nutrition Board in order to estimate how much vitamin A butter could be expected to furnish in the human diet from month to month throughout the year.

It is not essential that the day-to-day consumption of vitamin A be the same as the recommended daily allowance. When more vitamin A is consumed than is required for immediate use, the excess is stored in the body and used later when the diet is deficient in vitamin A. Possibly under ordinary circumstances an adequate amount of vitamin A would be obtained if the average daily intake from month to month approximated the recommended daily allowance. Effort was made in this study, therefore,

to determine the average monthly potency of the milk and butter, both according to the month of production and the month of consumption.

SUMMARY OF THE RESULTS

The survey has not yet been completed in all of the cooperating States. It is expected that each State experiment station will publish a detailed account of its own work when it is concluded and that a final over-all report will be issued by the Technical Committee.

Some 3,500 representative samples of butter have already been analyzed, however, and the information thus obtained and evaluated by the Technical Committee seems sufficient to warrant a general appraisal of the vitamin A potency of the creamery butter produced and marketed in this country. The purpose of this publication is to present a brief discussion of the results now available on a Nation-wide basis in order to answer, entirely for practical purposes, the questions raised by the Food and Nutrition Board. The information bears mainly on three questions:

1. The vitamin A potency of the creamery butter produced in the various States.
2. The effect of commercial storage and handling on the vitamin A potency of butter.
3. The vitamin A potency of butter sold on retail markets in the United States.

Results are now available which indicate the vitamin A potency of the butter produced in creameries in 14 States. These States make nearly 64 percent of the creamery butter produced in the United States, and their combined output undoubtedly may be considered representative of practically all the creamery butter produced in this country.

In all but one State there was a distinct difference between the vitamin A potency of butter produced under winter-feeding conditions and that produced under summer-feeding conditions. About 36 percent of all the creamery butter is "winter" butter, and it has an average vitamin A potency of approximately 11,200 International Units per pound. About 64 percent of all creamery butter is "summer" butter, and it has an average vitamin A potency of approximately 18,000 International Units per pound.

Careful consideration of all the results of this study indicates that the average vitamin A potency of the total output of creamery butter in the United States is approximately 15,000 International Units per pound. Thus, when the people eat as much butter as they did immediately before the war (approximately 18 pounds per capita) butter furnishes about 740 International Units of vitamin A per capita per day, or about 14.8 percent of the daily

allowance (5,000 International Units) recommended for normal adults by the Food and Nutrition Board of the National Research Council.

The effect of commercial storage and handling on the vitamin A potency of butter was studied by seven of the State experiment stations, and the results indicate that the effect of storage and handling is negligible.

Four State experiment stations investigated the vitamin A potency of butter sold on retail markets in their respective areas and found no significant difference between the average vitamin A potency of the butter on the retail markets and the average of the creamery butter produced in this country.

Milk produced under winter-feeding conditions has an average vitamin A potency of 1,140 International Units per quart (4 percent fat basis) and that produced under average summer-feeding conditions has a potency of 1,800. The average potency of the total supply of milk which disappears annually for domestic consumption is 1,530 International Units per quart. When the disappearance of milk for domestic consumption in all forms averages 1.052 quarts per capita per day, as it did in 1941, milk and milk products furnish the total population of this country about 1,600 International Units of vitamin A per capita per day, or nearly one-third of the recommended allowance.

The results of this study afford a practical demonstration of the fact, previously established by many investigators, that the vitamin A potency of milk and butter is dependent on the quantity of carotene in the diet of the cow. Since much of the milk now produced in summer has a vitamin A potency of from 2,500 to 3,000 International Units per quart and some of the butter has well over 20,000 units per pound, it is apparent that much could be done to improve the average potency of the annual output by adopting better feeding practices in winter, and possibly in summer also.

PROCEDURES USED IN CONDUCTING THE SURVEY

Method of Determining the Vitamin A Potency of Butter.—The vitamin A content of the butter was determined by using the antimony trichloride method, taking into account the color given by other materials in the butter which react with this reagent. The procedure was a modification of the one used by Koehn and Sherman in analyzing cod-liver oil. During the course of the survey numerous laboratories tested the method with butter to which known quantities of crystalline vitamin A had been added and found that only about 93 percent of the vitamin A was recovered in the analysis. This loss of 7 percent was assumed to occur in

analyzing the butter samples in this survey, and the results given in International Units have been corrected for such loss except where otherwise noted. Results given in micrograms of vitamin A in this report have not been corrected.

The carotene content of the butter was determined by washing the carotene solution in Skellysolve B with either 92-percent methyl alcohol or 94-percent diacetone alcohol to separate the carotene from the other pigments in the butter, and then reading the carotene fraction either with a colorimeter or a spectrophotometer.

The above methods gave the results in micrograms of vitamin A and micrograms of carotene. In calculating the total vitamin A potency of the butter, 0.6 microgram of the carotene and 0.25 microgram of the vitamin A were each taken as equal to 1 International Unit of vitamin A.

Method of Obtaining Butter Samples for Analysis. — Most of the States that participated in the survey divided their butter-producing sections into areas in which butter was produced under more or less uniform conditions and collected samples of butter at weekly or monthly intervals from representative creameries in each production area. The number of samples collected depended on the capacity of the State experiment station to do the necessary analytical work. Fortunately some of the largest butter-producing States cooperated in the survey, and the extent of the sampling in these States leaves little doubt about the vitamin A potency of the butter they produce. Approximately 3,500 samples of butter have been analyzed by the 20 State stations that took part in this study.

VITAMIN A POTENCY OF CREAMERY BUTTER BY REGIONS

It will be noted in table 1 that the 3 regions represented in the survey produce more than 97 percent of the Nation's total output of creamery butter, and that the 14 States in which the samples were collected for analysis produce about 64 percent of the total output. It therefore seems reasonable to consider the results obtained in these 14 States as representative of practically all the creamery butter produced in the country as a whole. In fact, the 12 North Central States alone produce more than 77 percent of all the butter made in this country, and the 6 North Central States that participated in this phase of the survey produce more than 54 percent of the total. The results obtained in these 6 States undoubtedly represent closely the potency of the

butter produced in the North Central region and therefore at least 77 percent of the total production for the country.

TABLE 1.—*Amount and percentage of the total United States creamery butter output produced by the participating States and the regions represented*

Region represented	States in region	Annual butter production		States participating in survey	Annual butter production	
	Number	*Million pounds*	*Percent*[1]	*Number*	*Million pounds*	*Percent*[1]
North Central States...	12	1,324.9	77.1	6	934.1	54.4
South Atlantic and South Central States.	13	151.1	8.8	3	6.6	.4
Rocky Mountain and Pacific Coast States..	11	194.6	11.3	5	153.2	8.9
Total or average...	36	1,670.6	97.2	14	1,093.9	63.7

[1] Percentage of average Nation-wide output for 1942-43—i.e., 1,718,600,000 pounds.

The results for the 14 participating States in the 3 regions are summed up in table 2. Of all the creamery butter produced in these States, 35.7 percent may be considered as "winter" butter with an average vitamin A potency of about 11,000 International Units per pound; 64.3 percent is butter produced in summer months when the cows are on pasture, and it has an average potency of about 18,000 International Units per pound. The grand weighted average, obtained by using the production in all States in each group and the seasonal distribution in the participating States, is 15,529 International Units per pound, which is as close as one can approximate the average vitamin A potency of the total output of creamery butter in this country.

In table 2 it will be noted that the winter butter produced in the creameries in the various States of the North Central region is quite uniform in vitamin A potency, the average being about 10,863 ± 267 International Units per pound. The potency of the butter produced during the summer in this region varied considerably more than that produced during the winter, the average being 17,810 ± 870, and the coefficient of variation being about twice that of the winter butter. The average annual potency of the butter sampled and analyzed in the six North Central States, which produce 54 percent of all the butter made in this country, was 15,150 ± 535 International Units per pound.

TABLE 2.—*Vitamin A potency of creamery butter produced during the winter and summer months in 14 States*

Region, and participating State	Average yearly butter production			Average vitamin A potency per pound		
	Total	Winter months	Summer months	Winter butter	Summer butter	Annual
	Million pounds	*Percent*	*Percent*	*International Units*	*International Units*	*International Units*
North Central:						
Minn.	304.4	43.3	56.7	10,808	17,946	14,855
Wis.	151.2	34.6	65.4	10,663	18,884	16,039
Ohio	69.5	31.4	68.6	9,698	15,459	13,650
Iowa	241.0	37.4	62.6	10,946	17,434	15,010
Nebr.	93.3	36.5	63.5	11,287	20,667	17,030
Kans.	74.7	37.8	62.2	11,606	15,030	13,768
Total or average	934.1	38.3	61.7	10,863±267	17,810±870	15,150±535
South Atlantic and South Central:						
N. C.	1.8	29.5	70.5	9,674	16,253	14,312
La.	.8	29.2	70.8	12,283	18,068	16,379
Miss.	4.0	22.8	77.2	12,014	17,868	16,533
Total or average	6.6	25.4	74.6	11,301	17,471	15,903
Rocky Mountain and Pacific Coast:						
Wash.	32.0	17.8	82.2	12,162	19,827	18,467
Ore.	28.2	34.7	65.3	12,899	18,464	16,535
Calif.	43.2	19.0	81.0	15,140	18,968	18,241
Idaho	37.1	37.1	62.9	13,312	18,197	16,384
Mont.	12.7	29.7	70.3	18,636	22,018	21,014
Total or average	153.2	26.9	73.1	13,931	19,170	17,754
Grand total or average	1,093.9	35.7	64.3	11,160	17,955	15,529

EFFECT OF STORAGE ON THE VITAMIN A POTENCY OF BUTTER

The laboratories at the Wisconsin, North Carolina, Minnesota, Ohio, California, and Mississippi Agricultural Experiment Stations investigated the effect of storage on the vitamin A potency of butter. Samples of butter were handled and stored under various practical conditions. The results indicate that both carotene and vitamin A are very stable in butter under the conditions tested; that little if any loss of vitamin A potency occurs during the periods that commercial butter is ordinarily stored; and that, insofar as the effect of storage is concerned, one would not expect the average vitamin A potency of the butter sold on the retail markets in this country to be significantly different from the average of the creamery butter produced in the country as a whole. The results from each State on the effect of storage are briefly as follows:

Wisconsin. — Investigators at the Wisconsin Agricultural Experiment Station stored four 64-pound tubs of butter at −21° to −23° C. The tubs were unparaffined, lined with parchment paper, and closed with wooden lids. There was no change in either the vitamin A or carotene after storage for 8 months.

They also stored seventy 1-pound packages of butter in original paper wrappings and cartons for 5 months. Ten of these samples were then analyzed. These samples showed no loss of either vitamin A or carotene.

North Carolina. — At the North Carolina Agricultural Experiment Station samples of butter collected during August and November, 1943, were analyzed and then stored at 10° F., for 3 months or 6 months. The investigators found no loss of either carotene or vitamin A as a result of storage; as a matter of fact, the carotene values in all cases showed "an embarrassing increase" of from 0.1 to 0.3 microgram per gram.

Minnesota. — At the Minnesota Agricultural Experiment Station one 10-pound tub of butter was collected from each region each month during the first 6 months of 1943. After a sample was taken from each tub for immediate analysis, the tubs were stored at −10° F., and other samples were subsequently withdrawn and analyzed after storage periods of 3 and 6 months. The average (weighted) carotene and vitamin A content of the 52 tubs of butter was as follows:

	Micrograms per gram of butter	
	Carotene	*Vitamin A*
Storage period:		
Fresh	2.97	5.16
3 months	2.97	5.38
6 months	2.93	5.50

These results indicate that the carotene content of the butter was little affected by storage. In the case of the vitamin A content, the Minnesota investigators concluded that the "very disturbing anomalous increases after storage" must be attributed to an uncontrolled error in the experiment. For

the data as a whole, however, the differences in the vitamin A content of the butter before and after storage are statistically insignificant. Certainly there is no evidence of deterioration in potency during storage.

Ohio. — At the Ohio Agricultural Experiment Station 156 samples of butter were stored at 0° F. for 6 months, and 96 of these samples were stored for 12 months. No loss in vitamin A occurred but the carotene content was slightly lower after storage, which indicates there was little change in total vitamin A potency of the butter. The results were as follows:

	Micrograms per gram of butter	
	Carotene	*Vitamin A*
Storage period:		
156 samples:		
Fresh	5.30	4.97
6 months	5.23	5.02
96 samples:		
Fresh	4.51	4.53
12 months	3.84	4.62

California. — The California Agricultural Experiment Station purchased six samples of butter at three different markets on June 2, 1943, and determined the carotene and vitamin A content at the time of purchase and also after 7 months' storage. The averages for the six samples were as follows:

	Micrograms per gram of butter	
	Carotene	*Vitamin A*
Market butter:		
When purchased	6.02	7.46
After 7 months' storage	5.91	6.70

The California investigators stated that 1-pound prints, from which these samples were taken for analysis and scoring, even when carefully rewrapped, can hardly be expected to yield the same results after storage as tubs of butter similarly tested. Significant losses in 6 months and 1 year of storage occurred in the tub butter of only one creamery. This creamery had only a small operation, and frequently the cream was 4 days old at the time of churning, and required fairly heavy neutralization. This interfered with the test.

Montana. — The average carotene and vitamin A content of 15 samples of butter analyzed by the Montana Agricultural Experiment Station before and after storage was as follows:

	Micrograms per gram of butter	
	Carotene	*Vitamin A*
Storage time and temperature:		
Fresh	5.62	10.10
30 days at 40° F.	5.46	12.69
90 days at 0° F.	5.67	10.73
180 days at 0° F.	5.28	9.01

It would be difficult to be certain that there was a significant change in either carotene or vitamin A as a result of the storage of these samples: certainly there was no obvious change as a result of storage for 90 days, and one might even question the significance of the difference between the carotene and vitamin A content of the fresh samples and those stored for 180 days.

Mississippi. — At the Mississippi Agricultural Experiment Station butter samples were obtained monthly from three different creameries over a period of 14 or 15 months. The samples were analyzed immediately after the butter was made and again after storage for 15 and 30 days at 45° F. The results, which indicate there was practically no change in either the carotene or the vitamin A content during storage, were as follows:

	Micrograms per gram of butter	
	Carotene	*Vitamin A*
Storage period:		
Fresh	5.9	5.88
15 days	5.6	5.90
30 days	5.7	5.83

In addition to the above samples, other samples were taken from the same source during certain months and stored for 5 months at 0° F., then analyzed. They were again stored for 15 and 30 days more at 45° and the results of the analyses were substantially the same as those above.

VITAMIN A POTENCY OF BUTTER ON RETAIL MARKETS

Butter produced under summer or winter feeding conditions may appear on the retail markets in the same month it was produced, or it may not be sold for consumption for some months after its production. Thus the amount of vitamin A available to consumers of butter each month throughout the year varies with the relative amounts of the high-potency summer butter and the lower potency winter butter marketed in the different months. It would be difficult to determine how much summer or winter butter is actually marketed or consumed each month, but the following studies of the vitamin A potency of butter on retail markets in four States indicate that the consumer may expect to obtain butter most of the time which compares favorably in its average vitamin A potency with the over-all average of all the creamery butter produced in this country.

New York (Cornell). — This station studied the vitamin A potency of the butters sold on the retail markets in Syracuse (population 206,000), which is served by 650 grocery stores, including the chain stores. Areas were selected in the city to represent different levels of consumer income as well as differences in the size and type of stores. In each store visited, a sample was purchased of each brand of butter for sale. Thus a number of samples of the same brand were obtained from different stores. The complete results of this very interesting survey will be published later by the Cornell workers. The results that bear on the over-all average vitamin A potency of market butters are shown below These results, which are not corrected for loss in analysis, compare very well with the same figures for the creamery butters produced in such States as Minnesota Wisconsin Iowa, and others.

	Average Vitamin A Potency International Units Per Pound
Samples collected:	
1943:	
April	15,781
June 1-2	16,062
June 28-29	19,916
August	20,870
September	17,770
October	19,372
November	16,652
Average of 1943 monthly averages (unweighted)	18,053
1944:	
January	12,998
February	10,700
March	12,220
April	9,294
May	10,523
Average of 1944 monthly averages (unweighted)	11,147
Average, all monthly averages (unweighted)	15,180

Pennsylvania. — The Pennsylvania Agricultural Experiment Station analyzed about 100 samples of butter purchased on the retail markets in the State, which represented six different brands of butter. Five were nationally advertised brands and one was the product of a local creamery. The results, which have not been corrected for loss in analysis, were as follows:

	Average Vitamin A Potency International Units Per Pound
Samples collected:	
1943:	
October	21,640
November	20,958
December	17,524
1944:	
January	13,494
February	10,299
March	9,547
April	9,447
May	10,057
June	13,192
July	17,610
Averages (unweighted):	
January to May, inclusive	10,570
June to December, inclusive	18,185
All months	15,100

Alabama. — The Alabama Agricultural Experiment Station determined the vitamin A potency of butter made on farms in the State. The samples were collected from retail markets in Alabama. Drought conditions in the summer of 1943 probably affected the potency of all the butter produced in the State in that year. The results, corrected for loss in analysis, are given below:

	Average Vitamin A Potency
	International Units Per Pound
Farm butter:	
1943-44:	
January	10,571
February	11,434
March	13,582
April	15,320
May	17,235
June	14,861
July	17,920
August	15,769
September	13,738
October	13,725
November	14,767
December	10,535
Averages:	
December to March	11,393
April to November	15,511
Annual	14,284

Texas. — The Texas Agricultural Experiment Station determined the vitamin A potency of 62 samples of market butter sold in Texas in 8 different months in 1942 and January 1943. The study was started prior to and independently of the present Nation-wide survey, and the method of analysis was different. But allowing for this difference in analytical methods, the monthly averages compare favorably with the averages for the creamery butter studied in such States as Wisconsin, Minnesota, Iowa, and others.

	Average Vitamin A Potency
	International Units Per Pound
Samples collected:	
1942:	
January	16,796
March	15,888
April	19,520
July	17,250
August	13,618
September	17,703
October	14,027
November	14,980
1943:	
January	17,250
Average of monthly averages	16,344

POSSIBILITIES FOR IMPROVING THE VITAMIN A POTENCY OF MILK AND BUTTER

There is ample experimental evidence that the vitamin A potency of milk, and also of the butter made from the milk, can be readily changed by increasing or decreasing the quantity of carotene in the cows' ration. The large increases in the vitamin A potency of the summer butter over the winter butter produced in the 14 States for which results are given in table 2 no doubt reflect an increase in carotene consumption by the cows when they were put on pasture.

The question as to whether or not there are conditions other than the quantity of carotene in the feed that affect the efficiency of its utilization by the cow has not been investigated adequately. It is obvious, however, from the large amount of experimental work in various laboratories, that any condition which tends to increase the lushness of pastures or the carotene content of winter-fed forages — either silages or hays — will increase the vitamin A potency of milk and butter very greatly. Hays that are cured in such a way that they retain their green color are rich in carotene, whereas hays that have lost their green color in curing may be very poor sources of carotene. Alfalfa hays may be rich sources of carotene or they may be worthless in this respect; timothy hays may vary manyfold in their carotene content. Silages made from corn, hays, and other crops lose very little carotene during storage if properly made and stored, but the carotene content of the silage will depend on the carotene content of the crop at the time it was harvested and ensiled. Most crops decrease rapidly in carotene content as they mature or lose their green color.

Much improvement in the vitamin A potency of the milk and butter produced in this country could be brought about immediately if the present knowledge concerning suitable farming and feeding methods were more widely put into practice. Improvements in pasture management and the development of more practical and economical methods of producing, processing, and preserving forages to increase the carotene content of the dairy ration would contribute to further improvement in the vitamin A potency of the milk and butter. Investigations along these lines are now in progress in many States. Similar studies are being conducted cooperatively by the Bureau of Dairy Industry and the Bureau of Plant Industry, Soils, and Agricultural Engineering of the United States Department of Agriculture. It has been recommended that the State stations and Federal laboratories cooperate

in such a program to improve the vitamin A potency of milk and butter just as they have cooperated in the present survey.

According to the figures in table 2, the average vitamin A potency of the fat in the winter butter produced in the United States was about 30 International Units per gram (1 pound of butter, or 454 grams, contains 80 percent fat) and that of the summer butter was 49 International Units per gram. On this basis one may calculate the average vitamin A potency of milk (4 percent fat content) to be 1,140 International Units per quart for winter milk and 1,800 for summer milk. Approximately 40 percent of the milk consumed (as milk or milk products) by the people in the United States is winter milk and 60 percent is summer milk. Thus, the average vitamin A potency of the milk consumed annually is 1,530 International Units per quart.

The "disappearance" of milk "for domestic consumption in all forms" in the United States in 1941 was equivalent to 1.052 quarts per capita per day. This amount of milk apparently furnished 1,600 International Units per capita per day for the total population, or approximately one-third of the 5,000 International Units of vitamin A recommended by the Food and Nutrition Board as the daily allowance for a normal adult.

This is a large contribution by the dairy industry to the national need for vitamin A. But if, by proper feeding, the vitamin A potency of winter milk were increased to that of summer milk, that is, to 1,800 International Units per quart, the same amount of milk that was consumed in 1941 would furnish about 1,894 International Units per capita per day, or nearly 40 percent of the daily allowance for a normal adult.

To what extent it may be possible to improve winter milk depends on the results that may be obtained by investigators, farmers, and others in improving the methods of conserving carotene in hays and silages. Further improvement in summer milk is also possible; the conditions which produce a lush pasture rich in carotene also produce more feed and more milk, as well as better milk.

Pasture grasses and other roughages are the principal source of the carotene used by dairy cows for the manufacture of vitamin A. The farmer may waste much of the carotene produced by his roughage crops or he may conserve it for human use if it is to his advantage to do so. Of course, it is to his advantage to feed as much carotene as his cows require for normal growth and health and to bear normal calves. But if he were to try to produce winter milk as rich in vitamin A as average summer milk, he would have to feed his cows much more carotene than they would need merely to maintain normal health or to bear normal calves. In-

creasing the carotene content of the diet of a normal cow does not increase her milk yield. Therefore, any farm practice which may be recommended as a means of increasing, beyond certain limits, the vitamin A potency of milk or butter for human food purposes must have economic advantages for the farmer in addition to those now recognized, or else be compensated for by "trade" considerations.

REPORTS BY COOPERATING STATES

Some of the cooperating State agricultural experiment stations have issued separate reports which deal with some phase of the vitamin A survey. The Department of Agriculture does not have copies of the State reports for distribution; all requests for them should be directed to the respective States. The State reports are as follows:

VITAMIN A POTENCY OF OHIO BUTTER. Ohio Agr. Expt. Station, Wooster.

VITAMIN A POTENCY OF IDAHO BUTTER. Idaho Agr. Expt. Station, Moscow.

VITAMIN A CONTENT OF LOUISIANA MILK AND BUTTER AS RELATED TO NATURE OF PASTURE. Louisiana Agr. Expt. Station, University Station, Baton Rouge.

THE VITAMIN A POTENCY OF COMMERCIAL BUTTERS SOLD IN TEXAS. Texas Agr. Expt. Station, College Station.

DETERMINATION OF THE CONTENT OF CAROTENE AND VITAMIN A IN WISCONSIN BUTTER. Wisconsin Agr. Expt. Station, Madison.

DISTRIBUTION OF CAROTENE AND VITAMIN A IN BUTTER-MAKING. Wisconsin Agr. Expt. Station, Madison.

THE VITAMIN A POTENCY OF CREAMERY BUTTER PRODUCED IN MINNESOTA. Minnesota Agr. Expt. Station, University Farm, St. Paul.

VITAMIN A CONTENT OF CALIFORNIA-PRODUCED BUTTER. California Agr. Expt. Station, Davis.

THE VITAMIN A CONTENT OF ARIZONA BUTTER. Arizona Agr. Expt. Station, Tucson.

EFFECT OF LIGHT ON THE STABILITY OF THE CARR-PRICE COLOR IN THE DETERMINATION OF VITAMIN A IN BUTTER. Kansas Agr. Expt. Station, Manhattan.

DETERMINATION OF VITAMIN A AND CAROTENOIDS IN BUTTERFAT. Indiana Agr. Expt. Station, La Fayette.

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